STATION PAPER NO. 43
December, 1956

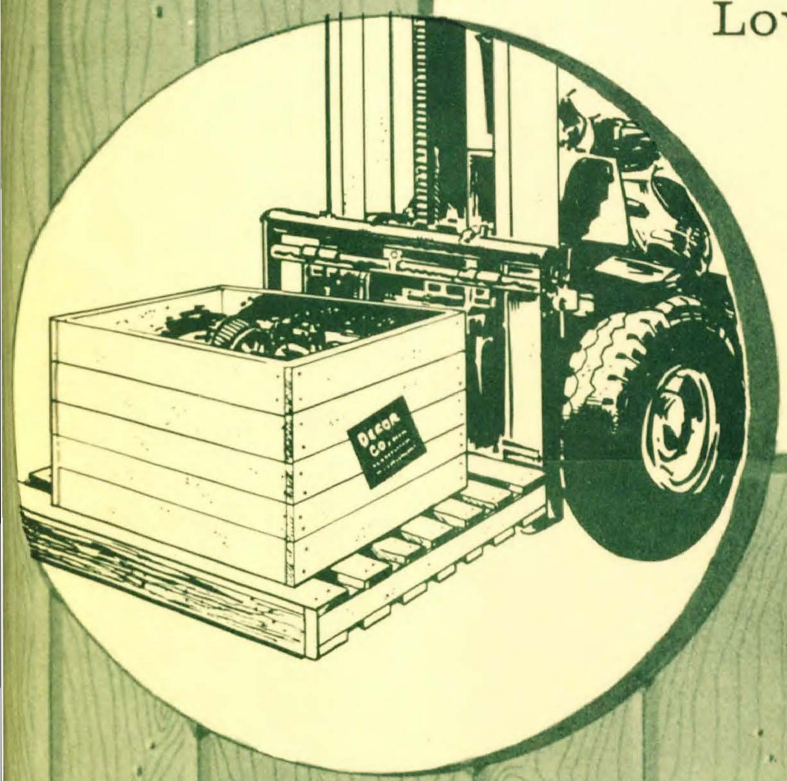
FOREST PRODUCTS MARKETING

WOOD PALLETS

IN THE MINNEAPOLIS—ST. PAUL AREA:

An outlet for

Low-grade Hardwoods



by

John R. Warner
D. R. Cowan

LAKE STATES FOREST EXPERIMENT STATION
M. B. Dickerman, Director

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

C O N T E N T S

	Page
INTRODUCTION	1
GROWTH OF THE WOOD PALLET INDUSTRY	3
Development nationally	4
Efforts toward pallet improvement	4
Production outlook	5
WOOD USED AND TIMBER AVAILABLE	6
MANUFACTURERS	8
Location and size of producers	8
Wood procurement	11
Investment in buildings and equipment	11
Transportation	12
PALLET USE IN THE TWIN CITIES	14
Pallet variability, form, and quality	15
Pallet life	18
Maintenance and repair	18
Loan and rental arrangements	19
DISTRIBUTION SYSTEM	21
How sales are made	21
Attitude of agents toward pallet sales	21
Details of sales negotiation	23
Price formation	24
Trade promotion	26
Relative merits of direct versus indirect sales	27
SUMMARY AND CONCLUSIONS	29
APPENDIX	31
Glossary of terms used	31
Grouping of woods according to nail-holding qualities and other properties of importance in container construction	33

WOOD PALLETS IN THE MINNEAPOLIS-ST. PAUL AREA: AN OUTLET FOR LOW-GRADE HARDWOODS

by

John R. Warner and D. R. Cowan[1/]

I N T R O D U C T I O N

Recent forest surveys in the Lake States Region have shown that more hardwood timber is available for cutting than is being utilized by existing industries. Conditions vary considerably by species and locality, but surplus volumes exist in most places. Generally speaking, the surplus consists mostly of low-quality wood--low by current utilization standards from the standpoint of species, size, shape, or logging chance.

One locality with rather large surpluses of hardwood timber is in central and southern Minnesota, tributary to the Minneapolis-St. Paul metropolitan district. Survey data indicate that a 56 percent increase in the present cut of sawtimber and a far larger increase in the cut of small bolt material would actually improve forest conditions of this area.

The solution to utilizing the surpluses lies partly in putting more local timber through established channels and partly in finding new uses for available timber.

1/ Foresters, Lake States Forest Experiment Station. The Station is maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minnesota, in cooperation with the University of Minnesota.

USDA-SCS-MILWAUKEE, WIS. 1956

In 1954 the Lake States Forest Experiment Station, in cooperation with the School of Forestry of the University of Minnesota, started a series of marketing studies dealing with potential outlets for products made from low-grade hardwoods. This report concerns wooden pallets--one of the products adapted to the use of lower grades of lumber. It is devoted primarily to a description of the existing market, the distribution system, and the manufacturing set-up.

The data used in this report were developed by interviewing. The courteous assistance of individuals closely associated with the manufacture, distribution, and use of pallets is deeply appreciated.

GROWTH OF THE WOOD PALLET INDUSTRY

A pallet is a sturdy, low platform (fig. 1) on which objects may be stacked to facilitate their movement and storage with mechanical lift equipment. Its utility and growing popularity may be explained by these basic advantages:

1. Savings in labor through less loading and unloading and less repeat handling.
2. Savings through better utilization of vertical warehouse space.
3. Savings through reduction of damage to articles moved.
4. Savings in time.

Figure 1.--This is a double face, nonreversible, flush stringer, two-way wood pallet designed for stacking materials on only the top face and for movement by both wheel lift and fork lift machines. (A wheel lift truck raises its load for movement by extending its wheels through the pallet base. See Appendix for glossary of terms used.)

Development Nationally

The origin of pallets is vague and reports are conflicting, but the first ones seem to have appeared in the early twenties with the successful construction and operation of a lift truck.

In 1938 the Navy experimented successfully with pallets as a part of a warehouse and port terminal expansion program. The subsequent servicewide adoption of the pallet system initiated a revolution in materials handling. With the stimulus of World War II, palletization grew quickly to maturity under pressures that rapidly improved mechanical lift equipment and explored every promising use for pallets. The young pallet industry could not meet requirements of mushrooming military demand and so thousands of rural woodworking plants and sawmills over the nation became part-time pallet producers. Estimates place total production for the military from 1941 through 1945 at roughly 90 million pallets.

Some firms began to use pallets before the war, but this early use by industry was a small trickle by comparison with the flood to start with the war's end. Industrial pallet use is estimated to have increased from near nothing in 1946 to 23 million units in 1950; in 1955 43 million pallets were produced, utilizing over a billion board-feet of lumber.2/

Efforts Toward Pallet Improvement

A number of national organizations have contributed toward pallet improvement and standardization. One, the National Wood Pallet Manufacturers Association, had its origin in 1946 as a division of the National Wood Box Manufacturers Association. In 1954 it became an independent full-time trade association. Four pallet distributors who market pallets on a national scale and three societies are also interested in improving the product.

Pallet specifications improved markedly during the war. The importance of such design characteristics as wood density, moisture content,

---

2/ Much basic information on pallets is contained in "Pallets and Palletization;" National Wood Manufacturers Association Handbook on "Wood Pallet Construction and Usage," 19 pp., illus. 1954.

board thickness, and effective fasteners was soon recognized. Five sets of specifications are now generally available: 3 military, 1 other federal, and 1 industrial.3/

Much information on pallets has been gathered at the U. S. Forest Products Laboratory in Madison, Wis. Since 1943 the Laboratory has cooperated with the Navy on a variety of pallet studies.4/ After the war the Navy also began a pallet research and development program at the Naval Supply Research and Development Facility in Bayonne, N. J. Industrial users and private laboratories conducted other research. The results of much of this work are publicized by the American Society for Testing Materials.

Production Outlook

Many large firms have now completed the shift to the pallet system. Orders from smaller firms and replacement orders are becoming more frequent, and with increasing industrial activity, indications are that this pattern will continue.

The use of pallets by smaller companies is proving successful. Credit for this belongs primarily to manufacturers of fork lift equipment, who have steadily improved design of their product, offered a wider choice of models, and advertised effectively. Credit too is due their

---

3/ Copies of specifications can be obtained as follows:

Bureau of Supplies and Accounts, Navy Department, Washington 25, D. C.: (1) Military Specifications MIL-P-15011 (S&A) "Pallet, hardwood, four-way 40"x48", nailed construction, general purpose;" (2) Military Specifications MIL-P-16496 (S&A) "Pallet, softwood (hardwood posts), 40"x48", four-way, nailed construction, general purpose;" and (3) Military Specifications MIL-P-15943 (S&A) "Pallet, wood, 48"x72", two-way, stevedore cargo."

Any regional office of the U. S. General Services Administration: Federal Specifications NN-P-71 "Pallets; materials-handling, wood."

National Wood Pallet Manufacturers Association, Barr Bldg., Washington 6, D. C.: "Minimum standard specifications for warehouse or returnable wooden pallets."

4/ A bibliography of this work is contained in "The wood pallet industry, its development and progress toward standardization," by Ralph K. Day, Forest Products Lab., No. 1957, 21 pp., illus. (Processed.)

area dealers. If the fork lift truck industry succeeds in broadening the market still further, it will be through the close cooperation of both manufacturer and dealer.

Some pallet firms are supplementing production by manufacture of repair parts. Stringers and deckboards are cut to size, and various items are planed, chamfered, and predrilled where necessary. This demand for parts by industrial firms with large pallet inventories is fairly recent, but promises to increase as the pallet and fork lift scheme of materials handling matures.

The present situation for pallet suppliers of the Minneapolis-St. Paul metropolitan area may be typical of the national picture. Many are optimistic regarding the future of the industry. Of 22 producers, only 2 felt that demand was decreasing. Two others felt that production would stabilize at the present level. Eighteen looked for moderately increased production.

WOOD USED AND TIMBER AVAILABLE

Within the region influenced by the Minneapolis-St. Paul market, hardwoods account for the entire volume of pallet production. The summary below indicates the approximate volumes of the various species manufactured into pallets during 1954 by firms that supplied the Twin Cities markets; about one-third of this was used in pallets for the Twin Cities.

Hard maple	- 2,000	M board-feet
Oak	- 1,600	" " "
Birch	- 1,100	" " "
Ash	- 400	" " "
Aspen	- 400	" " "
Elm	- 300	" " "
Other	- 300	" " "
Total	- 6,100	

With the exception of aspen and a small portion of the volume listed as "other," these species are Group III or Group IV hardwoods, as designated by the U. S. Forest Products Laboratory.[5/] Hard maple, oak, and birch, the three most heavily used species, are components of Group IV--so designated because of their high density, which provides them with excellent shock resistance and good nail-holding power. White ash in Group IV and other ash species in Group III are of minor importance in pallet manufacture.

Elm, usually designated as a component of Group III, is used in the stringers of many pallets. In this role it serves well, but as a pallet deck it often warps badly, particularly when subjected to extremes of moisture.

Aspen is listed under Group I, which includes species of low density. An important part of its present use is in experimental lightweight expendable pallets, but the larger volumes flow to industries where severe and frequent use make pallet life short. Truckers, whose work probably subjects pallets to the greatest strain, have been the most enthusiastic about the ability of aspen to outlast the denser woods when handling frequency is high. This is because it has greater resiliency and less splitting tendency and is easier to repair than pallets made from dense hardwoods. Every manufacturer who produced pallets from aspen did so to facilitate movement of aspen volume in the lower lumber grades accumulated in the manufacture of other products. Two firms made pallets from Grades 2 and 3 of aspen lumber, two others utilized only Grade 3, and one operated on Mill Run.

Use of the denser hardwood species narrows down almost entirely to No. 3 Common lumber and, in many cases, to specific breakdowns within this grade.

The matter of timber supplies need not restrict the expansion of pallet production in this area. Let us consider the survey district making up most of southern Minnesota and reaching west and somewhat north of the Twin Cities. The timber in this area is predominantly poorer quality oaks, elms, basswood, and other hardwoods. Total hardwood inventory is nearly 3 billion board-feet. Approximately two-thirds of this volume is in No. 3 sawlogs, which are suitable for pallets and other products made of lower grade lumber but are poorly suited for many other industrial purposes.

5/ See Appendix for a full breakdown of species into Groups I, II, III, and IV.

Estimated possible annual cut consistent with good forest management is 74½ million board-feet whereas the actual cut reported in 1953 was but 47-3/4 million board-feet, showing an available surplus volume of 26-3/4 million board-feet in this district alone. Adjacent areas in Minnesota, Wisconsin, and the Upper Peninsula of Michigan have even more abundant supplies of hardwood timber. Fuller utilization of this low-grade hardwood resource would undoubtedly provide forest managers with the economic environment necessary for widespread forest stand improvement.

MANUFACTURERS

Nineteen firms supplied Twin Cities industries with pallets during 1954. Five were located in Minnesota, 8 in Wisconsin, 3 in the Upper Peninsula of Michigan, and 3 in Alabama and Arkansas. Another 8 firms have shipped pallets to the cities in other years but were not active during 1954.

Location and Size of Producers

These producers are located in a half-circle around the industrial hub of Minneapolis and St. Paul (fig. 2). This distribution is due to the natural occurrence of timber resources in the region. The land south and west of the cities is mostly farmed and open, that to the east and southeast has considerable oak, and that to the north is mostly northern hardwoods, aspen, and conifers.

Nearly 102,000 pallets were sold in the Twin Cities area in 1954. Over 90,000 of these, or 89 percent, were supplied by 16 Lake States producers. The total output of these regional firms during 1954 is estimated at about 250,000 units of which nearly two-thirds went to other markets, primarily those in Chicago and Milwaukee.

With a commodity of low unit value and high unit weight, manufacturers are very sensitive to transportation costs. But they also take into account the availability of suitable timber, local labor costs, and other factors. Over 70 percent of the pallets brought to the Twin Cities were manufactured within 200 miles of this market, but only 5 percent within the first 50 miles. The advantage of close proximity to the market was more than offset by high labor costs. Higher bids for workers by Twin Cities industries appear to be effective within a radius of at least 30 miles. Beyond this, demand slackens enough to provide a labor market more favorable for pallet production.

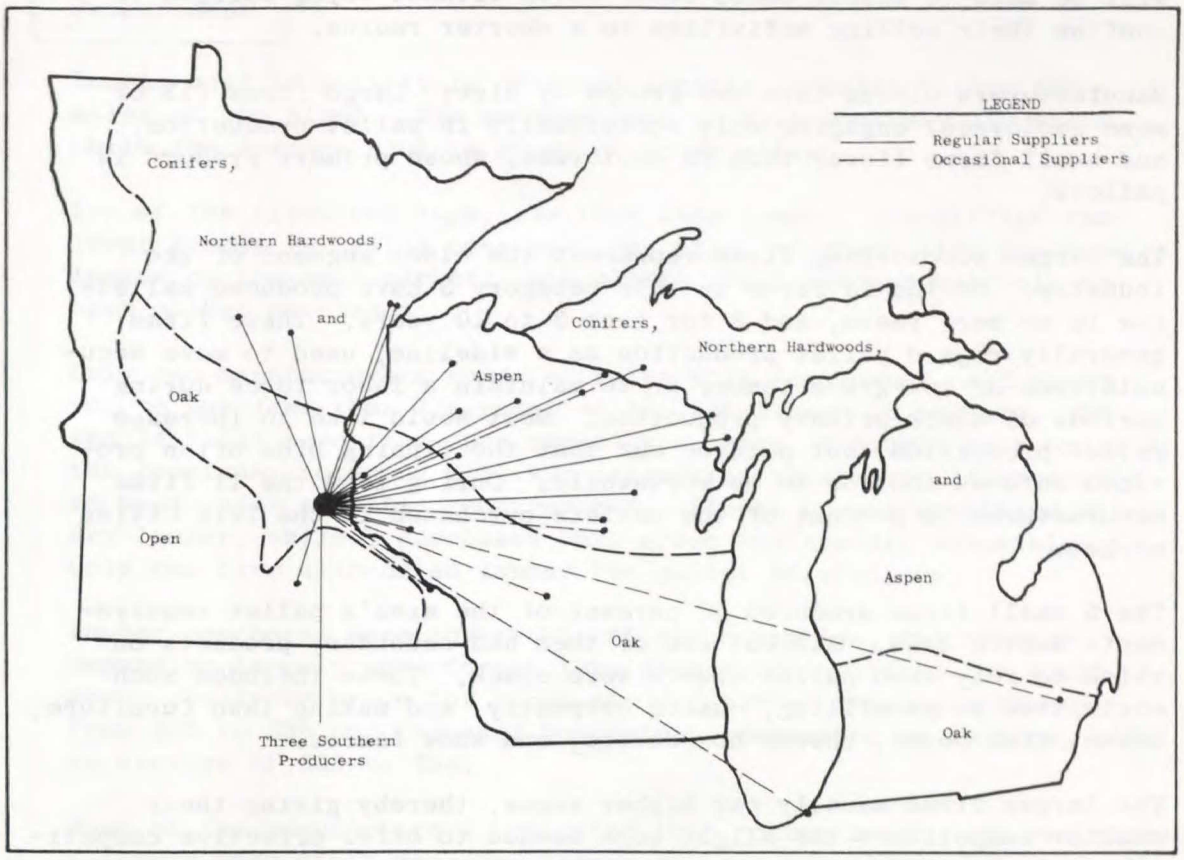


Figure 2.--Location of regional pallet manufacturers supplying the Minneapolis-St. Paul market, 1954.

Surprisingly, three southern mills accounted for slightly more than 11 percent of the total pallet volume entering the Twin Cities during 1954. All had to ship their products 500 to 1,000 miles by rail, a real disadvantage with respect to one important element of cost. These firms are large manufacturers. Their ability to compete stems from lower wage scales and lower raw material costs, as well as the efficiencies of high volume production.

One of these advantages may be removed by federal legislation which, as of March 1, 1956, raised the national minimum hourly wage of workers engaged in the manufacture of goods for interstate commerce

from $0.75 to $1.00. The Twin Cities market appears to be in a fringe area for the South. It remains to be seen whether the southern firms will be able to absorb added labor costs without being obliged to confine their selling activities to a shorter radius.

Manufacturers divide into two groups by size: Large firms (13 or more employees) engaging only occasionally in pallet production, and small firms (fewer than 13 employees) whose primary product is pallets.

The larger woodworking firms represent the older segment of the industry. Of the 11 firms in this category 3 have produced pallets for 10 or more years, and 8 for from 5 to 10 years. These firms generally regard pallet production as a sideline, used to move accumulations of low-grade lumber or to maintain a labor force during periods of slack primary production. Most would like to increase pallet production, but pointed out that the winning bids often provided returns too low to be worthwhile. During 1954 the 11 firms manufactured 59 percent of the pallets purchased in the Twin Cities market.

The 5 small firms produced 30 percent of the area's pallet requirements during 1954. All but one of them had secondary products on which to rely when pallet orders were slack. These included such activities as sawmilling, custom carpentry, and making lawn furniture, boats, fish boxes, cheese box covers, and snow fences.

The larger firms usually pay higher wages, thereby giving their smaller competitors the slight edge needed to offer effective competition. During 1954, the average worker of the larger firm received approximately $1.25 per hour, while pay for similar work in the smaller shop was $1.05. This wage differential, although offset somewhat by the efficiencies of large-scale operation, better production facilities, and closer control, is enough to exclude many larger manufacturers from the pallet market by making it difficult for them to place winning bids. The effect, generally, has been to encourage small firms to enter the business.

Every manufacturer, regardless of size, reported strong highs and lows in production and, despite specific conflicts, an overall seasonal cycle was evident. During 1953-54 production was high in late fall and early winter, declined to a low by spring, and then rose steadily during the summer and early fall, again reaching a high in December. Variation in demand is, of course, closely associated with general business activity, but additional study is needed to show the causes and the possibility of creating greater stability throughout the year.

Wood Procurement

Lumber used in pallets is obtained locally, usually within 100 miles of the plant. The maximum haul is approximately 150 miles, while the average haul is about 40 or 45 miles.

Ten of the firms buy logs, saw them into lumber, and utilize the lower grades in pallet construction; eight of these also purchase lumber on the open market. Six plants are dependent entirely on open market purchases.

Only two manufacturers reported using Mill Run lumber, and their volume was less than 3 percent of the total used in pallets. Of the 14 mills reporting open market purchases, 5 bought only Grade 3; the remainder accepted Mill Run deliveries which were later graded to meet their specific requirements. Eleven buyers specified air-dry lumber, while 3 purchased both green and air-dry material. Only one firm kiln-dried lumber for pallet manufacture.

Lumber purchases were invariably of mixed species, the mixture depending largely upon forest type distribution within the local area. Delivery price for rough air-dry lumber generally ranged from $48 to $58 per thousand board-feet, depending on species, with an average of $53 to $54.

None of the manufacturers indicated that volume supply was restricted, although complaints were registered of poor overall quality. Speaking generally, mills were finding it difficult during the summer of 1954 to move their stocks of lower grade material. An abundance of low-grade hardwood in the trade channels of the region is not uncommon, but during this period conditions were further aggravated by an extremely poor tie market. On at least four occasions, lots of lumber were sold at distress prices to pallet manufacturers; each sale was soon followed by an unusually low winning bid for a pallet order.

Investment in Buildings and Equipment

Owners and managers found it difficult to estimate building investment. For most, the specific investment required for pallet production was small. Buildings and equipment of woodworking shops

and lumber companies are easily adapted to pallet manufacture and, in every case but one, initial production began with use of such facilities. Plant investment in buildings ranged from as little as $500 to as high as $40,000, with the average estimated at approximately $10,000 (fig. 3).

Contrary to general opinion, efficient pallet manufacture requires a sizable investment in machinery and equipment. The major items considered essential were cutoff saws, rip saws, nailing tables, and a shaper (to chamfer boards). Most of the firms had a planer, electric hand drills or a multiple bank drill or both, and trucks. Other items reported were fork lifts, air hammers, a joiner, live rolls for moving lumber, moisture gauge, band saw, carloading equipment, and a dry kiln. Investment in equipment ranged from about $1,000 to over $60,000, with an average of about $25,000 per plant.

Although opinions of the minimum capital necessary for an efficient scale of production varied, the majority thought that an investment of at least $30,000 to $35,000 in building and equipment was necessary to compete effectively.

Transportation

The mode of pallet transport from manufacturer to user depends on distance. Trucks provide more efficient transportation for short hauls than do railroads (fig. 4). Many firms considered that the point of equal cost was close to 200 miles, although others were of the opinion that it was nearer 130 to 140 miles. All firms favoring the shorter rail hauls were well situated with regard to rail service.

Pallets are transported by rail on a straight lumber rate. They apparently have no commodity rate assigned to them despite the fact that their form necessitates a considerable volume of dead air space per carload in contrast to the close piling of a carload of lumber.

During 1954 trucks delivered 72 percent of the Twin Cities pallet purchases, while railroads moved the remaining 28 percent. Excluding southern production, truck deliveries were 82 percent compared with 18 percent by rail.

Figure 3.--The yard and buildings of a Wisconsin pallet manufacturer represent average facilities.

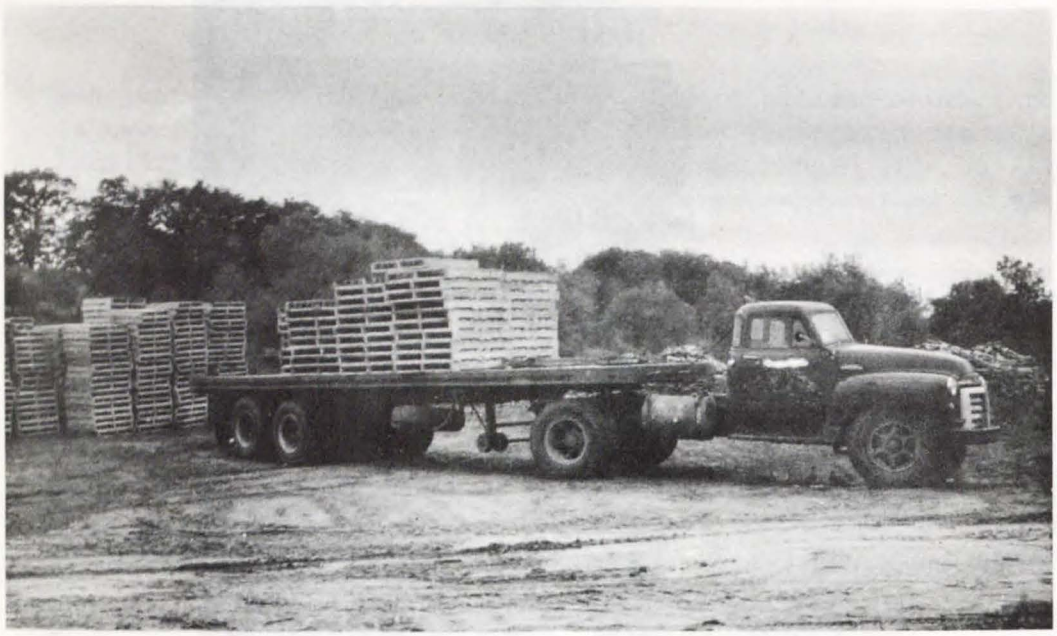


Figure 4.--The convenience, availability, and versatility of truck transportation make it the most widely used mode of shipping pallets for distances up to approximately 200 miles.

PALLET USE IN THE TWIN CITIES

Minneapolis and St. Paul are a natural distribution center serving the states of Minnesota, Montana, Wyoming, North and South Dakota, Nebraska, Iowa, Wisconsin, and Upper Michigan. The Twin Cities metropolitan area contains roughly 2,000 manufacturing firms, 2,000 wholesale establishments, 100 trucking terminals, and 9,000 retail outlets. The manufacturers, wholesalers, and truckers predominate as pallet users.

Use of pallets in the Twin Cities has increased rapidly in the last 10 years. Today, palletization of most large firms has been virtually completed. Medium and small businesses now comprise the greatest potential market.

Pallet Variability, Form, and Quality

A number of factors influence pallet design, notably:

1. Material being handled: Physical properties such as overall dimensions, shape, and weight; type of container such as bags, boxes, crates, and cartons; destination or end-use of product--for example, industrial or consumer.

2. Size of desired unit load.

3. Storage area characteristics: Headroom, floor load-weight limits, doorway sizes, ramps, elevators, aisle widths, and bay sizes.

4. Movement characteristics: Type and model of lift truck; frequency of handling.

5. Intended disposition of pallet: Retained in storage; used in shipment (ownership retained or ownership transferred).

6. Price per pallet.

7. Users' preference or habit of placement of pallet orders.

These many factors lead to the existence of a large number of pallet sizes--31 different sizes were purchased by Twin Cities firms during 1954 (table 1). Although 7 of these accounted for 79 percent of the pallets, suggesting a degree of standardization, actually no standard sizes exist. Pallets are custom made to meet each user's specific requirements.

The majority of Twin Cities users favor the nonreversible pallet (fig. 1 on page 3), which is suited to both wheel lift and fork lift trucks. It is built with a pair of wide spacings between the lower deck boards to accept the protruding wheels of motor walk trucks and thus has only one usable face. The reversible pallet has two identical faces and is designed for use only with fork lift equipment.

Users generally prefer the two-way pallet, which permits entry from either end. There is no present indication that pallets with four- or eight-way entries will gain substantial popularity in the Twin Cities.

Table 1.--Pallets purchased by Twin Cities firms during 1954 by size and relative importance 1/

Item	Pallet size 2/	Pallets purchased	Volume per pallet 3/	Total volume	Remarks
	Inches	Number	Board-feet	M bd.-ft.	
1	40 x 32	20,650	18.1	374	(23 percent of the pallet sizes in use account for 79 percent of the bd.-ft. volume)
2	40 x 48	13,200	23.7	313	
3	48 x 42	12,700	24.6	313	
4	36 x 48	11,150	21.6	241	
5	40 x 42	9,850	21.5	212	
6	32 x 40	7,700	16.4	126	
7	40 x 40	4,550	20.5	100	
8	48 x 40	2,000	25.5	51	(77 percent of the pallet sizes in use account for only 21 percent of the bd.-ft. volume)
9	48 x 48	1,650	29.0	48	
10	36 x 42	2,250	19.7	44	
11	48 x 36	1,400	23.8	33	
12	39 x 50	1,200	24.1	29	
13	36 x 40	1,500	19.1	29	
14	54 x 36	1,000	27.3	27	
15	32 x 48	1,050	18.6	20	
16	42 x 48	700	25.4	18	
17	36 x 36	950	17.8	17	
18	30 x 36	1,150	14.0	16	
19	36 x 30	1,000	15.8	16	
20	32 x 32	1,050	14.2	15	
21	48 x 60	400	34.2	14	
22	42 x 60	400	30.0	12	
23	44 x 48	400	26.9	11	
24	30 x 42	600	16.6	10	
25	42 x 42	400	23.0	9	
26	42 x 56	300	28.5	9	
27	13 x 24	1,500	5.4	8	
28	33 x 36	450	15.8	7	
29	32 x 42	250	17.0	4	
30	42 x 66	100	32.3	3	
31	42 x 36	150	20.8	3	
Total		101,650	-	2,132	

1/ The source of these data is from manufacturing firms and manufacturers' agents active in pallet production and distribution within the Twin Cities market, 1954.

2/ First dimension is stringer length of pallet in inches.

3/ Computed for nonreversible pallets with 3 stringers and 2" deck spacing.

The field of expendable pallets from paper and wood is potentially an important one. Factors giving impetus to this development are: The labor savings and increased speed of handling when products are left stacked on pallets in shipping from manufacturer to ultimate consumer; avoidance of the inconvenience and additional cost of returning empty pallets; and the fact that railroads bill pallets at the same rate as the commodity they carry rather than as dunnage. In general, the several forms of expendable pallets developed to date have had their adaptability and usefulness restricted by their strength or form limitations. Some require special lift attachments before they are serviceable.

Acute price consciousness is shown by most companies in initial pallet procurement. Their insistence on the lowest possible price frequently results in pallets of a quality not fully suitable for the purpose intended. Reorders, on the other hand, are conditioned by experience in use, and although there is still strong insistence on holding down costs, concessions are being made to quality improvement.

With increasing experience, users become more aware of the details of pallet construction and of the specific changes that would improve both utility and service life. They no longer are preoccupied with overall dimensions but give increasing attention to other items such as the advantages of various fastener types, the rounding of corners, full width stringers, moisture content of wood, predrilled deck boards, and minimum widths and thicknesses of deck boards and their spacings. For example, a chain food store in reordering insisted on pallets with bolted deck boards because of the frequent repair necessary with boards held by nails. On the other hand, a trucking firm tried but discontinued the use of bolted pallets because their serviceable life was not appreciably longer than for nailed pallets and the time consumed on their repair was prohibitive. Thus, the search of users for a balance between quality and price in pallets is a continuous one.

Inspection is advantageous to both user and manufacturer. However, as a means of quality control in the Twin Cities inspection has not been widely used, mainly because pallets are often considered a minor item in operations. As a substitute for inspection, buyers commonly request a sample pallet as a guide in selecting a manufacturer. Because these samples are not always representative of the order received later, the requests have gravitated to what is called a "minimum sample pallet." In theory such a sample is no better than the worst to be found in the order and may, if necessary, be used as a standard for inspection. Actually since wood varies widely in form and quality it is difficult to construct a pallet which embodies all the defects that could occur in the average order. Furthermore producers dislike to sell their merchandise in a highly competitive market with a sample constructed of material of lower than average quality.

Pallet Life

There are a number of causal factors contributing to pallet damage and consequently to pallet life. Some of them are:

1. Careless and irresponsible handling by warehouse employees such as: Pushing over a stack of empty pallets; pulling the top pallet from a stack and allowing it to fall to the floor (a fall on a corner racks a pallet severely).

2. Rough and inexperienced handling with lift equipment such as: Picking up a loaded pallet without stopping the truck; using the truck to push a loaded pallet into entry position without maneuvering the truck; pushing a loaded and raised pallet against a pillar or wall to straighten the load.

3. Overloading, improper loading, and loading with odd-shaped bulky objects.

4. Strapping objects to pallets which have a bottom surface area smaller than the deck of the pallet, thus pulling off upper deck boards.

5. Outdoor storage of pallets not in use.

Useful pallet life ranged from 25 days with a trucking firm to an estimated 10 to 12 years in warehousing (fig. 5). Several firms who purchased pallets in 1946 are still using most of them, and their present condition indicates an additional 1 to 5 years' service. Pallet life is directly proportional to the frequency of movement.

Maintenance and Repair

Pallet maintenance and repair soon becomes a concern of purchasers. Most repairs are made by personnel already employed, and only rarely is the job performed on a contract basis. Boards cut to size, predrilled where necessary, and assembled into kits are available from pallet manufacturers. Where repair becomes a continuing function, these ready-to-use parts soon pay dividends through savings in time and labor. During the past few years the use of precut repair parts has expanded rapidly, and a steady future increase is indicated. However, users generally felt that if repair costs exceed one-half the original cost the pallet should be either junked or salvaged in the repair of others.

Figure 5.--Typical of the lift equipment used in storage warehouses is this electric-powered lift truck, which is being used with a two-way nonreversible pallet.

Average repair cost appears to run between $1.10 and $1.50 per pallet, while the overall average repair rate (the number of pallets repaired per year as a percentage of total pallet inventory) falls between 10 and 15 percent per year for total pallets in use. The repair rate varies widely for different industries and conditions of pallet uses. One trucking firm estimated that each pallet in its inventory was repaired on an average of once every week. These pallets were moved as often as 30 times each day. The other extreme is illustrated by a warehousing firm in which the average pallet was moved only 13 times a year with a yearly repair rate of only 3 per 100 pallets.

Loan and Rental Arrangements

Some people in industry feel that many of the problems of materials handling could be solved by some form of pallet pool. Such a pool could operate successfully only on a national basis, with warehouses for pallet storage strategically located throughout the country. Pallets would be available to customers on a rental basis. One company did establish a pallet rental service of this type, but financial difficulties forced it to suspend pool operations in 1947 and sell its pallets

to its various renters, some of whom were Twin Cities firms. Whether the increased use of pallets since 1947 would mean success for a similar rental organization today is a matter of conjecture. The difficulties associated with revival of a nationally operating pool are considerable and make its reestablishment remote. The most severe of these could be summed up as follows:

1. Successful establishment and operation would depend heavily on a rapid rise in rental volume. Since heavy pallet users have already met their requirements through purchase, early rentals would probably be dominated by small numerous contracts expensive to locate, sell, and administer, and rapid in turnover.

2. The pallet has basic disadvantages as a rental item. It is easily procured and maintained, and low in purchase cost--all of which favor pallet acquisition by the individual firm. Furthermore, the rental firm would be confronted with difficult problems of warehousing, maintaining, and keeping tab on so large a number and so great a variety of low-unit-cost items.

3. In rail transport pallets present another problem. Railroads do not recognize them as a commodity; hence pallets travel at the same rate as the commodity they carry or, when a carload of empties is returned, at the commodity rate for lumber. For an organization engaged in renting thousands of pallets this lack of agreement with railroads for rate adjustment schedules on pallet transport would be a major problem.

The nearest approach to a pallet pool in the Twin Cities is the reciprocal pallet loan agreements in effect among several St. Paul-Minneapolis firms and among branches of larger corporations. There are indications that pallet exchange agreements may be reached in the transfer of goods between sizable Twin Cities manufacturers and companies in other parts of the country. However, this form of pallet exchange is dependent upon reciprocal trade and will always be limited.

DISTRIBUTION SYSTEM

The pallet distribution system is influenced primarily by the initial dependence of manufacturers on local representation, their distance from the market, the low unit value of pallets, and the close association of pallet use with lift truck equipment.

How Sales Are Made

Pallet sales vary considerably in character according to whether they are initial orders or reorders. In Minneapolis and St. Paul, the proportion of reorders has been rising constantly and at present constitutes more than half of the pallet transactions. This trend parallels experience in Milwaukee, Chicago, Detroit, and other eastern cities where palletization developed earlier. In those cities most purchases are now for replacement or expansion.

Because of the distance between them and their customers, many pallet manufacturers have agents in the large markets. In the Twin Cities 10 of the 24 truck and lift equipment dealers are agents; they accounted for 50 percent of the pallet sales volume in 1954. An out-of-town agent handled another 4 percent. The remaining 46 percent was sold directly by the manufacturers. However, the 8 manufacturers who relied exclusively on direct selling accounted for only 19 percent of the total sales volume.

Occasionally shipments of pallets enter the Twin Cities in response to orders placed with manufacturers' agents in other cities who are also represented locally. Several lumber companies in Chicago have functioned as middlemen for such shipments.

Attitude of Agents Toward Pallet Sales

The 10 equipment dealers representing pallet manufacturers in the Twin Cities have permanent forces of salesmen, each of whom sells the entire line including pallets. Most of the equipment dealers who do not have an agency for a pallet producer either refer inquiries to one of the 10 agents without charge or transmit orders to these agents on a shared-commission basis.

Most of the pallet sales are made in conjunction with equipment sales or are transacted as a special service for past and potential equipment customers. Salesmen, most of whom work on a commission basis, do not actively solicit pallet orders unless the orders promise to be exceptionally large.

The principal reason for this sales reluctance and "service" attitude toward pallets on the part of agents is the relatively low return on pallet sales. All of the pallet manufacturers' agents feel that their commission is insufficient to pay for special selling effort. The commission on pallets, usually about 5 percent, contrasts sharply with the 10 to 15 percent on fork lift trucks, and 15 to 20 percent on powered pallet trucks. Since pallets must be designed for a specific function, the time requirements for sales often approach those of the more lucrative equipment transactions.

The field of consumer recognition is relatively uncultivated in the pallet market. Few wooden pallets carry trademarks. Manufacturer names have gained little familiarity through advertising. Consequently, agents receive negligible aid in selling and must take the initiative in establishing acceptance for the product they handle. The absence of quality standards in pallet manufacture sometimes results in shoddy or incorrect construction. Dissatisfaction with such construction is often associated by the customer with the name of the dealership, since manufacturer names are not familiar. Moreover, the agent must expend additional time in negotiating adjustments when specifications are not fulfilled.

Other sources of dissatisfaction arise when commission payments are tardy or when delivery dates are not met. Also, bids are occasionally submitted on an order by several agents, each of whom is unaware that others are quoting for the same producer.

Though such undesirable practices are not characteristic of all pallet manufacturers, the frequency of their occurrence has been sufficient to darken the reputation of the pallet industry among equipment dealers and customers. Pallet manufacturers can hardly expect much selling effort in their behalf by agents as long as they are unwilling to back up the agents with exclusive territories, quality standards, dependability of delivery, remunerative commitments, and loyalty.

In spite of their avowed disinterest in pallet sales, those industrial equipment dealers who maintain pallet agencies feel that pallets are an essential part of their line. The explanation of this seeming paradox lies in the close association between pallets and fork lift equipment. With pallets available, a customer can completely implement his fork lift pallet system through one dealer. Salesmen feel that this can be the margin of success in closing a difficult transaction. Moreover, potential equipment customers make themselves known through

pallet inquiries. These arguments for carrying pallets are apparently potent; the 10 equipment dealers representing pallet manufacturers account for most of the fork lift sales in the Twin Cities.

Resales of pallets and sales of repair kits tend to be more attractive to manufacturers' agents than new orders. The sales commission remains constant while costs decline. Experienced customers know what pallet specifications fit their needs, their expectations for pallet appearance and performance are more reasonable, and a higher price on pallets is more acceptable after the budgetary strains from initial investment have eased. Completion of the transaction seldom involves more than taking the order and relaying it to the producer.

However, the very ease with which the transactions are negotiated prompts customer and producer to bypass the middleman. This, of course, is disturbing to the middleman. It was he who introduced the manufacturer's pallets to the market, and his time in consultation helped to shape customer specifications. Just when his investment in selling time promises to receive recompense, he is eliminated from further transactions. It would seem that agents could improve this situation by establishing firmer and more stable ties with his manufacturer and by emphasizing his importance as a continuous representative with an established name in the market.

Details of Sales Negotiation

The receipt of an order or a request to bid on an order sets in motion the process of price determination for quotation purposes. An agent that represents more than one manufacturer must decide for which manufacturer (s) he will submit bids. Every agent must follow the agreed-upon method of price formulation for quotation.

Many factors influence a nonexclusive agent in deciding which of his several suppliers should be quoted on a particular inquiry. Since few customers express a preference, the decision largely rests with the agents. Some agents quote for all of their manufacturers. Others direct carload orders to their larger or more distant suppliers, the smaller orders being left to the plants which ship by truck. Quality is the basis used by one agent. He first determines the willingness of the customer to pay a premium for a better pallet and quotes accordingly. Naturally the price or delivery demands of customers frequently indicate for which producer a quotation should be made. Some manufacturers cannot meet customer demands because of their productive capacity or distance from the market. One agent, for example, allots the inquiries and orders to his producers according to their shipping distance from the scattered customers.

Most companies invite competitive bids on initial orders or large reorders. When an agent receives an inquiry on a large order (approximately 500 pallets or more) he forwards details of the order to the producer by mail, telephone, or telegraph before entering a bid quotation. The producer responds with price and delivery commitments and possibly some qualifications on the specifications.

Quotations on large orders, especially initial orders, are conventionally in writing and are prepared on the agent's standardized form. Half of the pallet agents use only verbal quotations on small orders unless instructed otherwise by the customer. The majority of the inquiries on the characteristically small replacement orders are not offered on a competitive basis--consequently, they seldom require written quotations. Agents feel that companies that have purchased pallets several times gradually limit their orders to one agent. The greater assurance of satisfactory production and delivery more than compensates for the possibility of a lower bid from a competitive source. Yet, some large firms hold to a policy of competitive bidding on all purchases including reorders.

Since relatively few purchasers of pallets provide complete specifications, the agent must provide a detailed description or sample of the pallet on which he is quoting. This protects the agent and his manufacturer from misunderstandings with inexperienced purchasers. It also allows the customer to compare product and price with those of competing firms. As stated previously, however, the present tendency to use a "minimum sample pallet" has not been altogether satisfactory.

When sales negotiations are complete and the pallets have been delivered, the purchaser must be billed by either the manufacturer or his agent. In this study 5 agents handled the invoicing of the customers for the pallet firms they represented; they withheld their commissions and credited the remainder to their accounts with the manufacturers. Another 4 agents left the billing and collection entirely to the producers, from whom they received the commission payments. The remaining agent, who represented two manufacturers, did all invoicing of customers for his local manufacturer. His other more distant supplier billed large companies with nationally known credit rating but left the invoicing of small local companies to the agent who was more cognizant of their financial status.

Price Formation

Prices for pallets in the Twin Cities fall into two categories--negotiated and established.

Negotiated prices are usually resolved by manufacturer and consumer (occasionally through agents) and are the most common method of arriving at the final price agreeable to both parties. When pallets are made to order, negotiations follow submission of specifications.

Established prices are set by several pallet manufacturers who permit agents to quote prices on small orders without preliminary factory contact. These manufacturers each provide their agents with one of three methods for computing the basic pallet price: (1) A current price per fabricated board foot is applied to appropriate entries in a table of lumber volumes (usually prepared by the manufacturer) for pallets of various dimensions and types; (2) a formula is used which combines applicable variables to produce a per pallet price; and (3) a list of products and corresponding prices may be provided. Regardless of the method used to compute the basic price per pallet, fixed increments are added for such special requirements as round corners and chamfered deck boards.

Though prices are essentially computed per board-foot, they are always quoted to customers on a per-pallet basis. Agents quote "f.o.b. mill" or "delivered" depending on customers' desires. If the f.o.b. point is not specified by the purchaser, two agents quote both ways, two quote "delivered," while the others quote "f.o.b. mill." Agents whose pallet suppliers are located at considerable distances from the Twin Cities are especially prone to exclude delivery charges in quotations. Some customers request that transportation and merchandise charges be itemized separately, since the two are handled differently for income tax purposes. This breakdown also provides customers a basis for comparing alternative modes of shipment.

Most manufacturers rely heavily on cost computations in setting price. They generally use past average total cost per thousand board-feet fabricated, and adjust it for special features such as chamfering, special nails, bolts, rounded corners, an urgent delivery and problems of transport, plus a margin of profit and risk. A second method, employed extensively by one firm, computes costs from a formula that considers the principal cost variables in manufacture; transportation, special adjustments, and a margin for profit and risk are then added.

The cost basis for pricing has certain obvious disadvantages. Costs depend not only on estimates for depreciation, which may be considerably in error, and for labor and materials which themselves are subject to changing costs, but also on an assumed volume of production which can vary greatly during the accounting period (normally one year). Hence, successful pricing depends on careful record keeping by the manufacturer and an accurate estimate of the near-future economic situation as it may affect his labor and suppliers as well as his prospective customers.

Direct costs (ignoring fixed costs such as rental and depreciation) are a valuable guide below which price cannot go, and should be used as a minimum under a certain volume assumption. If the manufacturer must price below that point he must also find some way to lower costs or stop production.

Manufacturers exhibited two general policies toward competition in determining prices. The first involved lowering the acceptable margin, and bids were entered when there seemed a strong likelihood that this minimum margin could be realized. The second was pricing below competition, either directly by simply underbidding in price, or indirectly by meeting price but giving additional service features or guarantees. The latter frequently happened when negotiations followed bidding and took on such forms as transportation at no extra cost, better nails, free spare boards, etc.

This policy leads members of the industry to use available funds or any unusual advantage, such as special bargains on lumber purchases, to attract business exclusively on a price basis rather than to gain more secure patronage through non-price appeals cultivated by promotion and aggressive selling. Lack of capital often means that getting an order is imperative, thereby forcing operations to a short-term viewpoint.

Trade Promotion

Generally, little effort or money has been devoted to establishing and promoting pallet brand names in the Twin Cities. It is worthwhile to consider why this is so, and to evaluate the desirability of a change. Five factors predominate:

1. Pallets bought on price appeal. At present users buy largely on price appeal and do not distinguish among products of various manufacturers. There are indications, however, that this may be changing with experience.

2. Quality "apparent" upon inspection. Purchasers feel that they can tell the quality of a manufacturer's pallet by inspecting one specimen pallet or a sample of newly delivered pallets. But much depends upon the integrity of the producer--type of nails used, moisture content, number of boards, hidden shortcomings, grade and species of wood, etc.

3. Relative importance of product to consumer. Pallets are considered an inexpensive supply item by most users. Though buying is rational, often little attention or concern is devoted to pallet purchasing. This point of view varies, depending upon size of investment and importance of pallets in operational efficiency of the firm.

4. Insufficient funds. Only the largest manufacturers of pallets are financially able to provide a significant promotional budget. Small dribbles of expenditure for advertising are usually ineffective and are probably better employed in price appeals or cost reductions.

5. Restricted markets. Because shipping costs add considerably to pallet price, the individual manufacturer has a relatively small sales area in which his promotional efforts are effective.

Advertising and promotional efforts by the pallet industry should be increased to provide educational information on and greater assurance of quality. There is growing evidence that price as a primary qualification among users is yielding to quality considerations and that the increasing demand for wood pallets provides a favorable atmosphere for advertising. Hence for the individual manufacturer a promotional drive should increase selective demand through building confidence in a name and associating this name with certain quality standards.

Relative Merits of Direct Versus Indirect Sales

At present manufacturers differ on the relative merits of direct and indirect sales. Some have done their own selling, others have relied on manufacturers' agents exclusively, while the rest have combined the two methods of distribution. Which strategy is the most suitable? No unequivocal answer can be offered for the pallet industry as a whole; the solution is specific to the individual enterprise and depends on the factors below.

1. Nature of the product. A pallet is an industrial product that may be capital equipment or a supply accessory, depending on its life expectancy in a particular use. (a) The nature of its use calls for specific design specifications, technical advice, and other services that require specialized sales knowledge. (b) Pallets are nearly always produced to user specifications. (c) Initial

orders are large while (d) reorders are generally in smaller quantities. (e) Purchases of pallets by individual customers are infrequent and unpredictable, necessitating continual sales contact to keep the manufacturer's name before the customer. Points b and c add weight to the choice of direct sales, while d and e favor the use of manufacturers' agents. Point a calls for salesmen familiar with the properties and use of pallets whether employed by manufacturer or agent.

2. Nature of the market. The principal markets for pallets are, like the Twin Cities, metropolitan centers of commerce and industry. (a) Pallets are usually produced near lumber sources in rural areas at significant distances from the market. (b) Potential customers are lift equipment users scattered throughout the metropolitan market. (c) These customers characteristically desire advice on designing a pallet to mesh with their overall materials-handling system. (d) They feel that better price arrangements can be negotiated directly with a manufacturer, but (e) favor having a representative near at hand to adjust complaints and back up guarantees. The use of equipment dealers as agents is recommended by a, b, c, and e. Point d supports direct selling.

3. Place of manufacturers' agents as distributors. (a) The industrial truck lift equipment dealers in the Twin Cities who act as pallet manufacturers' agents employ technically trained salesmen who are expert in a wide variety of equipment and materials-handling problems and are in constant touch with past and potential customers. (b) These dealers spread selling costs over a variety of noncompetitive products. (c) The equipment salesmen generally display passive interest in pallet sales and are unfamiliar with the manufacturing process and problems. (d) Occasionally they make unrealistic commitments in pallet sales in their zeal to close a large contract. Thus, a and b favor representation by agents; c and d lend doubt to such a policy.

4. Situation of the manufacturers. (a) As mentioned above, most manufacturers are at considerable distances from the market. (b) Few of them can support a sales force and, therefore, managers assume the sales responsibility. (c) Few manufacturers have had much past experience in selling to large industrial or commercial concerns. (d) Products manufactured jointly with pallets seldom move to the same type of customers so that selling costs cannot be shared. (e) Narrow margins on pallets limit selling and promotional expenditure. All of these points, of course, discourage the direct sales method.

SUMMARY AND CONCLUSIONS

1. Inquiry has been directed toward the current market and potential future demand for wood pallets in the Minneapolis-St. Paul area. This study is a part of an effort to increase use of low-grade hardwoods from nearby forests.

2. Within a 120-mile radius of the Twin Cities are more than 2 million acres of timberland, mostly in the form of scattered farmwoods. These woods are capable of yielding about 27 million board-feet of sawlogs more than are being cut now. The timber is of rather poor quality but much of it is suitable for making pallets.

3. In 1954, pallet users in the metropolitan area purchased about 102,000 wooden pallets representing 2.1 million board-feet of lumber. Few were manufactured within the Twin Cities but 70 percent came from within a 200-mile radius. Nineteen percent came from more distant parts of the Lake States; 11 percent were imported from the South. Additional pallets made in the Lake States for other than Twin Cities markets required another 4 million board-feet of lumber.

4. Local manufacturers generally make pallets as a part-time or sideline business. Profits are relatively low, but the business utilizes grades of lumber not readily employed for other uses and permits keeping men employed when other business may be slack. Most manufacturers would welcome an expansion of the market for pallets. Most expect a moderate growth in demand.

5. The possibilities for expanding pallet manufacture and sale in this area seem reasonably good. Most large manufacturers and distributors in the area have "palletized" already and offer a steady market for maintenance items and replacements. Innumerable smaller firms can be considered likely prospects for new business. Apparently timber supply presents no problem. Capital and manufacturing facility requirements are modest.

6. At present the pallet industry is not well organized for product improvement and market development. Profits to manufacturers and dealers have been insufficient to stimulate the research, education, and sales promotion needed to insure growth of the industry. Promotion of pallet use in the Twin Cities to date has depended a great deal upon activities of fork lift equipment salesmen. As replacement pallets and repair parts become increasingly important in production, manufacturers have a tendency to arrange direct sales rather than sell through agents. Thus they remove much of the incentive that local representatives should have to develop new business aggressively.

7. Competition in many cases has been too largely on a price basis, without consideration of quality and service. This, plus the indifference of some buyers to using specifications, has sometimes led to an unsatisfactory product, tending to discredit pallets in the eyes of many users and agents.

8. From the above it appears that problems of product improvement, sales promotion, and distribution rather than questions of raw material supplies or manufacturing facilities are the principal obstacles to a wholesome expansion of pallet business in this area.

APPENDIX

Glossary of Pallet Terms Used[6/]

Two-Way Entry.--This design permits entry of mechanical handling equipment from two sides only in opposite directions.

Four-Way Entry.--This design permits entry of mechanical handling equipment on all four sides.

Eight-Way Entry.--This design is similar to four-way pallets but with posts arranged to provide for entry of mechanical handling equipment, not only from all sides but diagonally from the corners as well. (Of limited use except in warehousing.)

Single-Face Pallet.--This style has only one deck--the top surface.

Double-Face Pallet.--This style has both top and bottom decks and comes in two different designs:

a. Reversible--this style has identical top and bottom decks upon which goods may be stacked on either side. This is also referred to as a double-face pallet.

b. Nonreversible--in this style the top and bottom have different deck openings. Therefore, goods may be stacked only on the top deck.

Expendable Pallet.--Expendable pallets are designed for temporary use or on trip shipments. They are usually of economical construction and have minimum strength factors.

Pallet Sizes.--Dimensions should always be stated in inches with the length given before the width. The width should be given as the dimension parallel to the top deck boards.

Deck.--This can be subdivided into top and bottom decks. The top deck or face of a pallet carries the load. The bottom deck or face of a pallet helps to distribute the load more uniformly.

6/ From "The Wood Pallet Industry, Its Development and Progress Toward Standardization," by Ralph K. Day, Forest Products Laboratory, No. 1957, 21 pp., illus., 1953.

Deck Boards.--The boards which make up the decks or faces of a pallet; usually referred to as top or bottom deck boards.

Stringers.--These are wooden runners to which the deck boards are fastened, and which serve as a spacer between the top and bottom decks to permit the entry of tines of lift trucks.

Grouping of Woods According to Nail-Holding Qualities and Other Properties of Importance in Container Construction 7/

GROUP I embraces the softer woods of both the coniferous and the broad-leaved species. These woods are relatively free from splitting in nailing, have moderate nail-holding power, moderate strength as a beam, and moderate shock-resisting capacity. They are soft, light in weight, easy to work, hold their shape well after manufacture and, as a rule, are easy to dry.

Aspen (popple)	Magnolia
Basswood	Pine (except southern yellow pine)
Buckeye	Redwood
Cedar	Spruce
Chestnut	Willow
Cottonwood	Yellow-poplar
Cypress	
Fir (true firs)	

GROUP II consists of the heavier coniferous woods and includes no hardwood species. These woods usually have a pronounced contrast in the hardness of the springwood and the summerwood. They have greater nail-holding power than the Group I woods, but are more inclined to split and the hard summerwood bands often deflect the nails and cause them to run out at the side of the piece.

Douglas-fir	Tamarack
Hemlock	Western larch
Southern yellow pine	

GROUP III consists of hardwoods of medium density. No coniferous species are included. These woods have about the same nail-holding power and strength as a beam as the Group II woods, but are less inclined to split and shatter under impacts. Group III species are the most useful woods for box ends and cleats. They also furnish most of the rotary-cut lumber for wirebound and plywood boxes.

Ash (except white ash)	Sweet gum
Soft elm	Sycamore
Soft maple	Tupelo

7/ USDA, Forest Service, Forest Products Laboratory, Madison, Wisconsin, as revised May 24, 1954.

GROUP IV woods are hardwood species. They have both the greatest shock-resisting capacity and the greatest nail-holding power, but because of their extreme hardness, they present difficulties with respect to driving of nails and also have the greatest tendency to split at the nails. They are especially useful where high nail-holding power is required and many of them make excellent rotary-cut lumber for wirebound and plywood boxes.

Beech	Oak
Birch	Pecan
Hackberry	Rock elm
Hard maple	White ash
Hickory	

SOME RECENT STATION PAPERS

Forest Statistics for Minnesota, 1953.
Paul C. Guilkey, Bernard Granum, and R. N. Cunningham
Sta. Paper 31, 35 pp., illus. 1954.

A Review of Literature Relating to Quaking Aspen Sites.
M. L. Heinselman, and Z. A. Zasada.
Sta. Paper 32, 61 pp. 1955.

Oak Wilt Damage, A Survey in Central Wisconsin.
R. L. Anderson and D. D. Skilling.
Sta. Paper 33, 11 pp., illus. 1955.

Forest Management Lessons from a 1949 Windstorm in Northern Wisconsin and Upper Michigan.
J. H. Stoeckeler and Carl Arbogast, Jr.
Sta. Paper 34, 11 pp. 1955.

The Forest Insect Situation, Lake States, 1955.
L. C. Beckwith and H. G. Ewan
Sta. Paper 35, 15 pp., illus. 1956.

The Timber Resource of North Dakota.
John R. Warner and Clarence D. Chase.
Sta. Paper 36, 39 pp., illus. 1956.

Lake States Timber Resources.
R. N. Cunningham and Survey Staff.
Sta. Paper 37, 31 pp. 1956.

Publications of the Lake States Forest Experiment Station.
L. P. Olsen and H. A. Woodworth.
Sta. Paper 39, 130 pp., 1956.

Guide for Selecting Superior Forest Trees and Stands in the Lake States.
Paul O. Rudolf.
Sta. Paper 40, 32 pp., illus., 1956.